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FEDERAL COMMUNICATIONS COMMISSION
OFFICE OF SECRETARY

May 10, 1995

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Secretary of the Commission
Rulemaking No. 8577
Federal Communications Commission
1919 M Street, NW, Suite 200
Washington, DC 20554

Attention: William Caton

Dea Mr. Caton:

I am writing this letter to express my strong opposition to the Cellular Telecommunications Industry Association's petition to the FCC to override state and local regulations of antennas. The FCC's Public Notice of a Rulemaking of this petition was published on January 18, 1995, No. 8577.

Due to new scientific information I am opposed:

1. CTIA and Carlo charged with conspiracy to deceive public. Microwave News, Mar./Apr. 1995.
2. More stringent EMC standards suggested (for cellular telephones-- Biomedical Safety & Standards 25:49-51, Apr. 1995.
3. Cellular phone risk? USA Today, Apr. 28, 1995, p. B1.
4. Clutter on airwaves can block workings of medical electronics: reports trace interference to cellular phones, TV; safeguards are spotty. Wall Street Journal June 15, 1994.
5. Goldsmith, J. R. Epidemiologic evidence of radiofrequency radiation (microwave) effects on health in military, broadcasting, and occupational studies. International Journal of Occupational and Environmental Health 1:47-57, Jan./Mar. 1995

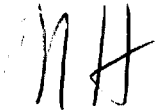
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023

6. The National Capital Planning Commission has established
Antennae Task Force
Enclosed are there recommendations
February 2, 1995.

I hope you will consider the new scientific information
and protect lives of millions of people.

Sincerely yours,

A handwritten signature in dark ink, appearing to be 'MH' with a stylized flourish.

Marija Hughes
Owner/Publisher

Cell Phone Company Manager with Brain Tumor Sues Motorola; CTIA and Carlo Charged with Conspiracy To Deceive Public

Debbra Wright, an Arizona-based manager for Bell Atlantic Mobile, has filed suit against Motorola Inc., charging that its portable cellular phones caused or aggravated her brain tumor. Motorola is also accused of failing to test the phones for safety or to warn users of health risks, and of conspiring with other parties to deceive the public about the health risks posed by cellular phones.

Others named in the conspiracy charge are the Cellular Telecommunications Industry Association (CTIA); Dr. George Carlo of CTIA's Scientific Advisory Group on Wireless Technology (SAG); Ron Nessen, CTIA vice president for public affairs and communications; and Carlo's consulting company, Health and Environmental Sciences Group Ltd.

Nationwide, there are now eight lawsuits pending that seek to link cellular phones to brain cancer, but this is the first by an employee of a service provider. It is also the first such case to name the CTIA, Nessen or Carlo as defendants. The suit, filed in an Illinois state court on March 2 in Chicago, is not expected to go to trial until 1998 or 1999.

"This case uncovers the methods the industry has used to avoid telling the truth to the public. It was decades before this happened in the tobacco industry, before their propaganda machine was exposed," said Wright's attorney, Robert Holstein of Holstein, Mack & Klein in Chicago. He said that Wright learned of her cancer in December 1993, on the same day CBS News announced Motorola engineer Robert Kane's lawsuit over his own brain tumor (see *MWN*, J/F94). Holstein's firm represents Kane and three other plaintiffs in similar cases, in addition to Wright.

Wright has worked in the cellular industry since 1988, first for US West Cellular and then for Bell Atlantic Mobile. "I used only Motorola's portable cellular phones," she said in an interview from her home in Gilbert, AZ, where she is recovering from her second round of brain surgery. "And I was a heavy user." She added that her tumor is located "exactly where I'd been holding the phone ever since I was in the business."

The defendants have issued strong denials. "We sympathize with the individual in question," said a press release from Motorola. "However, we have seen these same opportunistic lawyers before. They are dealing in junk science and baseless theories to pressure Motorola into out-of-court settlements."

"This case is not about safety or the scientific process," CTIA spokesperson Mike Houghton asserted in an interview.

"It's about greedy tort lawyers."

In a written statement, Carlo said, "I am unable to comment on any specific aspects of the lawsuit." But he insisted that, "The SAG's work is an open book."

The suit has drawn attention to a CTIA workshop held last December in San Diego, at which Carlo and Nessen were the main speakers (see box, p.12).

As an example of what it calls "the CTIA's deceptive and false pronouncements," the complaint cites a 1993 statement to the *Wall Street Journal*: "There have been thousands of studies that have shown these phones are safe."

When asked if the CTIA still stands by that statement, Houghton said, "Back in 1993 we said there had been thousands of studies that were either around, near or at the cellular range. As we've gone forward, as the SAG has been established, it has become apparent that more specific studies are needed.... The statement I'd make today is that there is no evidence that would lead us to suspect any biological reason why they might cause any harm."

Last November, Wright asked Bell Atlantic Mobile for any information they had on research showing that portable cellular phones are safe. "You know what they gave me a week later?" she recalled. "This little CTIA brochure folded in thirds. My manager said, 'This is all we have.' The truth is, there is no research proving safety. It's not there."

The brochure in question was printed in January 1993, according to Houghton. Titled *Safe Cellular Phones*, its first paragraph contains this sentence in bold: "The research has shown overwhelmingly that the radio transmissions from cellular telephones pose no health risk."

Asked whether the CTIA would say that today, Houghton answered, "It's not a yes or a no question. At that point in time, that is what was known." He added, "We take comfort in the fact that every day they *don't* find something is more evidence in support of our original proposition."

Wright insisted that, "You're not talking to a disgruntled, nonperforming employee." When she worked in phone sales for US West, Wright says, she was twice named salesperson of the year for the Southwest region. Just days before her suit was filed, she was promoted from assistant manager to manager of Bell Atlantic Mobile's real estate division in the Southwest.

"I've sold a lot of phones," said Wright, breaking into tears. "I might have jeopardized a lot of people's lives." But Wright

added that she takes comfort from the attitude of others who work in the cellular phone business. "I can't tell you the number of people in the industry who've called me giving support. They're saying that the truth has got to come out."

Carlo's attorney said that his legal expenses will be paid by the escrow fund established by the CTIA to finance the SAG's research effort. "Legal representation and liability coverage are normal operating expenses of the scientific research program," James Baller of the Washington law firm of Baller Hammett explained in a statement. Carlo and his consulting company are named as defendants in the lawsuit, but the SAG itself is not.

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Biomedical Safety & Standards®

April 15, 1995

TECHNICAL DATA CENTER

Volume 25, Number 7

FEATURE

More Stringent EMC Standards Suggested

The rapid growth in communications technology, especially cellular telephones, has prompted manufacturers, regulators, voluntary standards organizations and medical electronic device users to examine existing requirements (see *Biomedical Safety & Standards*® 24:41, April 1, 1994; 21:73, June 1, 1991; 23:1, January 1, 1993). FDA and others have been developing and harmonizing standards for radiofrequency emission measurement, test-method development and immunity testing. Ongoing Australian research, however, suggests that some existing standards for medical device electromagnetic interference (EMI) immunity and electromagnetic compatibility (EMC) should be raised.

Results of the study were presented recently at the *International Standards Conference on Medical Devices* sponsored by the Association for the Advancement of Medical Instrumentation and FDA.

EMC STANDARDS
continued on next page

CLINICAL SAFETY & PRODUCT HAZARDS

Patient Mistakenly Taken Off Respirator Dies

Human error and failure to accurately communicate instructions have been cited as common causes of adverse incidents in healthcare settings. Failure of hospital policies to properly address such human factors can increase potential liability (see *Biomedical Safety & Standards*®, 22:103, July 15, 1992). A patient at University Community Hospital (UCH - Tampa, FL) died less than an hour after a respiratory technician carried out a physician's orders on the wrong patient. In an interview with this newsletter, a UCH spokesperson commented that the patient was "taken off a ventilator and put on a trachea collar." The technician reportedly failed to properly identify the patient before carrying out the procedure. Subsequent attempts to resuscitate the patient failed. The spokesperson added that the patient for whom the procedure was intended was not in an adjacent bed. He said that the incident was still under investigation by outside consultants and state agencies and that the respiratory technician who made the mistake has been put on administrative leave.

The spokesperson indicated that the hospital's current policy is for employees to visually and, if possible, verbally confirm patient identities. Policy also dictates that a patient's identification bracelet and hospital room chart be checked. Acknowledging that new policies have been implemented, the spokesperson declined to discuss the changes until they are approved by the appropriate agencies. The accident occurred less than two weeks after a surgeon at the same facility amputated the wrong lower leg of a diabetic patient. Index: Ventilator, patient death; Patient death, ventilator.

BSS

The independent, concise news source written exclusively for the fields of medical safety and standards. Includes timely, factual reports on: safety hazards, product recalls, standards, legal actions, legislation & regulations, hospital safety, BMET & CE activities, education, and meetings.

FEATURE

EMC STANDARDS continued from cover

Researchers from the Australian Therapeutic Goods Administration, Australian Telecom Research Laboratories and Monash Medical Center (Melbourne) measured field strengths from several types of mobile telephones at various distances from devices. Leo Barnes, supervisor of the electromedical testing section of Testing and Certification Australia (Chatswood, New South Wales) stated that digital cellular telephone emissions are above 3 V/m at 2 m, the current IEC and collateral standard, however, they are below 10 V/m at 2 m. Barnes explained that the interference effects observed by researchers included false error conditions or equipment shut-

downs, an infusion pump changing infusion rates, and an oscilloscope blanking out. Existing FDA standards require a device to be immune from up to 7 V/m at 2 m. Although all of the medical devices in the study met the FDA standard, the researchers found that 8-W digital telephones can emit fields which exceed the FDA standard.

While Barnes indicated that a complete ban on cellular telephones in hospitals would be an over-reaction, he emphasized that the devices should be required to be turned off within 2 m of any medical equipment. He stated that it is necessary to specify "off," because when such a telephone is in "standby" mode it is still transmitting its identification information. The researchers also

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recommended that the immunity test level for medical equipment be increased to 10V/m; such a proposal is currently being considered by IEC. Index: Electromagnetic interference, cellular phones, standard; Cellular phones, electromagnetic interference, standard. BSS

For information on Australian EMC strategies, contact:

Australian Electronics Development Center
Cnr Riggall & Maldon Streets
Broadmeadows, VIC 3047, Australia
61-3-302-1422; FAX, 61-3-302-1201.

CLINICAL SAFETY & PRODUCT HAZARDS

Dialysis System Water Linked to Pyrogenic Reactions

Three patients in Philadelphia suffered pyrogenic reactions following dialysis using **Mar Cor Dialysis Water Systems**, manufactured by **Mar Cor Services Inc.** (Harleysville, PA), according to the firm. The company subsequently issued a safety alert to notify customers "to test their treated water to determine if it meets **Association for the Advancement of Medical Instrumentation** standards against microbiological contamination." A Mar Cor spokesperson told this newsletter that the incidents occurred because the incoming tap water had excess LALs. He noted that a century-old water main in the area of the hospital ruptured three days later. "There was an assumption that there was gray water [in the mains]," he added. To address the problem, he indicated that the firm was retrofitting affected units with a "0.05 absolute filter" to eliminate pyrogens. The company confirmed that "Medical Device Safety Alert" #N-005-5 affected units distributed in Pennsylvania, New York, New Jersey, Delaware, Alabama, Maryland and Virginia. Although the agency stated that 74 units were distributed, the firm indicated that only 22 units were affected. (Contact: Mar Cor Services Inc., 364 Maple Ave., Harleysville, PA 19438; (215) 256-9585; FAX, (215) 256-4551.) Index: Dialysis water systems, excess pyrogens, safety alert; Contamination, dialysis water systems, safety alert. BSS

Dry Heat Sterilizers Seized

Dry Heat Sterilizers, Steam Sterilizer Autoclaves and components valued at \$45,000 were seized because they allegedly lacked premarket approval, FDA stated. "The articles are class III

devices for which there are no approved pre-market approval applications in effect, nor do the articles have investigational device exemptions," the agency stated. The devices were manufactured by **D.A. Kadan Co. Inc.** (Pineville, NC). A company spokesperson stated that "everything is pending." Index: Sterilizers, unapproved devices, seizure. BSS

RECALLS & FIELD CORRECTIONS

Neonatal Ventilators Pose Electric Shock Hazard

Sensormedics Corp. (Yorba Linda, CA) has recalled its **Model 3100A High-Frequency Oscillatory Neonatal Ventilators** because "a wire next to the metal amplifier bracket may abrade, due to vibration, causing a potential electrical shock hazard," the FDA announced. The devices are indicated for the ventilatory support and treatment of respiratory failure and barotrauma in neonates.

A company spokesperson told this newsletter that, to correct the problem, the firm will add a caterpillar grommet along the edges of the sheet metal bracket to protect the adjacent power harness. He added that the company is asking users to check the leakage current; users are advised to schedule the modification at their convenience if it is below 100 μ A. If leakage current is above 100 μ A, the unit should be taken out of service and be corrected immediately, the firm stated. "Class II recall" #Z-497-5 affects units with serial numbers 31204 through 31848, excluding 31359 through 31378. The company confirmed that 625 units were distributed nationwide, and in Australia, Canada, Hong Kong, Korea, Mexico, Netherlands, Philippines, Singapore and Taiwan. The action is listed as "ongoing." (Contact: Sensormedics Corp., 22705 Savi Ranch Parkway, Yorba Linda, CA 92687-4609; (800) 231-2466; (714) 283-2228; FAX, (714) 283-8439.) Index: Ventilator, electric shock hazard, recall; Neonatal ventilator, electric shock hazard, recall. BSS

Nebulizer Leakage Deactivates Gas Supply

The FDA stated that **Vortran Medical Technology** (Sacramento, CA) has recalled certain units of its **VISAN-9 Intermittent Signal Actuated Nebulizers** because "gas leaks in the seams of the high-pressure transducer casing can trigger an alarm which then shuts off the gas supply."

USA Today, Friday, April 28, 1995, p. B1

CELLULAR PHONE RISK? A

study indicates digital cellular phones may interfere with cardiac pacemakers, when they are held near the device. Dr. David Hayes of the Mayo Clinic says that people who are "completely pacemaker dependent" should use "older analog models until we know more."

Siray Signals

Clutter on Airwaves Can Block Workings Of Medical Electronics

Reports Trace Interference
To Cellular Phones, TV;
Safeguards Are Spotty

A Heart Monitor That Failed

By TOM KNUDSON
And WILLIAM M. BULKELEY

Staff Reporters of THE WALL STREET JOURNAL

As life-saving electronic medical equipment becomes more sophisticated and sensitive, evidence has begun to pile up that these instruments are vulnerable to increasing levels of electromagnetic interference — the waves given off by radios, cellular phones and television sets.

The consequences can be frightening: A ventilator malfunctions while the child using it is riding in a car, and the problem is traced to the car's cellular phone. A doctor installs a pacemaker after electrocardiogram equipment shows a patient's heart isn't working right; nurses later trace similar — inaccurate — readings on the machine to TV signals. A woman dies inside an ambulance as paramedics try to revive her heart with a defibrillator — which doesn't work because of interference from the vehicle's two-way radio.

Although electromagnetic interference, or EMI, has been known to be a source of problems for some time, the widespread use of cellular phones, metal detectors, computers and other sources of radio energy is creating pressure for stricter controls.

Zapped Wheelchairs

Government safeguards are spotty, but concern is growing at the Food and Drug Administration. Last month, the agency ordered makers of motorized wheelchairs to shield them from EMI and educate users about the hazard. The FDA said it acted after getting "many reports of erratic, unintentional powered-wheelchair movement." In one such incident, according to a recent article by an FDA researcher, radio waves zapped a power wheelchair, sending its passenger over a cliff in Colorado, "causing a broken hip and several other injuries." The victim wasn't identified.

But only a few devices are subject to FDA review for electromagnetic vulnerability before they go on sale. "The problem is going to increase before it decreases . . . because of the proliferation of medical devices," predicts Joe Dyro, director of biomedical engineering at the State University of New York at Stony Brook. "There is still a lack of awareness of how to properly shield these devices."

EMI is a broad term for invisible waves and pulses, natural and man-made, that move through space and matter. Although the waves are usually harmless, certain devices will sometimes react to them, the way TV sets can pick up "snow" from a nearby hair dryer.

More . . .

WSJ 6/15/94

The Phone Ban

A few hospitals are starting to act. Earlier this year, St. Margaret Mercy Healthcare Centers in Hammond and Dyer, two Indiana towns, banned cellular phones after linking them to medical-device failures. So did Children's Memorial Hospital in Chicago last November.

"We've verified potentially dangerous interference with ventilators, electrocardiogram monitors, apnea monitors, infusion pumps, blood warmers, infant incubators, with the list continually growing," says Terry Clemans, St. Margaret Mercy's director of technology management. Mr. Clemans says cellular phones were interfering with signals sent by portable heart monitors carried by patients. Most large hospitals use such telemetry monitors to free patients from bedside machines.

Jeffrey Silberberg, an FDA electronics engineer, says the FDA has received reports of EMI being involved in more than 100 frightening and occasionally fatal failures of medical equipment going back to 1980. In the fall 1993 issue of the journal Compliance Engineering, he cited these cases and called for tighter regulation.

A Wall Street Journal request under the Freedom of Information Act resulted in the release of reports of the incidents, without the names of patients or sites. FDA regulations require companies to file the reports, although most manufacturers don't acknowledge product malfunctions in these cases.

A Fatal Case

Physio-Control Corp., an Eli Lilly Corp. unit in Redmond, Wash., reported that medical technicians taking a 93-year-old heart-attack victim to a hospital in 1991 attached her to one of the company's LifePak monitor/defibrillators to track and try to revive her failing heart. But they said the heart machine shut down every time the technicians turned on their radio transmitter. The woman died.

Michael Willingham, director of regulatory affairs for Physio-Control, says the radio waves were the source of the problem. He says company engineers discovered that the ambulance maker had replaced the metal roof of the vehicle with a fiberglass dome that didn't block radio waves well—then placed a powerful, long-range radio-transmission antenna atop it. Mr. Willingham says this is the only incident of its type involving LifePak.

In 1992, a doctor installed an apparently unnecessary pacemaker in a patient's chest after an electrocardiogram telemetry system made by SpaceLabs Inc., also of Redmond, displayed "long periods of flat line." That evening, the same phenome-

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More . . .

Stray Signals: Electronic Medical Gear Is Vulnerable To Interference From Cellular Phones, Television

Continued From First Page

non recurred. Nurses discovered that the patient was next to a TV set when the flat line occurred. "Current labeling has warning about TV interference with telemetry signals," SpaceLabs reported to the FDA.

"We've had only two or three instances of problems" with EMI, says John Hall, vice president of quality assurance at SpaceLabs. "Another kind of diagnostic would normally be done" before implanting a pacemaker, he adds, but the company "can't tell people how to practice medicine."

Some medical-products firms say they have long been aware of EMI, and add that it is standard practice to design systems to avoid it. Larry Saper, chairman of Data-scope Corp., a Montvale, N.J., maker of surgical devices, says, "In developing any device, you might discover wires are too close to one another. You move the wires and the problem goes away." Technicians installing electronic machines routinely check for interference.

'Black Art'

"We're dealing with a black art. A lot of this stuff is unconfirmed," says Joel Nobel, president of the Emergency Care Research Institute, a nonprofit organization in Pennsylvania that investigates medical devices. "I'm not saying there aren't problems—there are. But we don't know how frequent [or] significant they are."

Nevertheless, the proliferation of cellular phones and the growing use of medical electronics outside hospitals increase the chances of stray transmissions affecting delicate medical monitors. "We have a real concern and it has been growing as equipment has become more susceptible because of the use of micro-electronic, low-voltage circuits," says Bruce Burlington, director of the FDA's Center for Devices and Radiological Health.

One big problem is the elusive nature of EMI. "It's very, very hard to identify these events after the fact," says Michael Argenti, vice president for technology management at the Emergency Care Research Institute. "The problem is you can almost never reproduce them."

But sometimes you can come close. In May 1992, alarms sounded on five vital life-support ventilators in an intensive-care unit at Arkansas Children's Hospital in Little Rock. When nurses rushed to the devices, which help patients breathe, they found nothing wrong. But then a sharp-eyed respiratory therapist spotted a hospital shuttle bus outside.

"We started to think — could it be the radio on board?" says Pat White, a technician at the hospital. "One of the maintenance men pulled his radio off his belt, and standing in the middle of the room, close to the ventilators, keyed it up — and the same thing happened again." Mr. White says his

reaction was "panic — because of the amount of radios and cellular phones that float around this hospital."

Manual Revisions

The manufacturer of the ventilators, Siemens AG of Germany, says an investigation by an outside party hired by the company showed that other forms of EMI may have caused the malfunctions. Tim O'Malley, Siemens's director of marketing for ventilators in the U.S., says, "It's difficult to fix a problem when you really don't know what you're dealing with." The incident prompted Siemens to change its instruction manuals to warn about the risks of using two-way radios and cellular phones near its ventilators.

In June 1993, a ventilator made by Aequitron Medical Inc. malfunctioned while the child using it was in a car, says Ron Cundiff, director of security for Children's Memorial Hospital in Chicago, where the child was a patient. Mr. Cundiff says the machine began acting erratically when the child's mother used the car's cellular phone. "The readings started changing. And it started beeping," he says. "When she hung up, everything went back to normal."

Robert Samec, vice president of quality assurance and regulatory affairs at Aequitron, says that in subsequent testing the Minneapolis company discovered that cellular phones within three feet of a ventilator may set off the alarm. He notes that "the failure mode isn't catastrophic [because] generally the device will alarm and continue to ventilate the patient." The company has added warnings about cellular phones to its instruction manuals.

Aequitron previously had problems with EMI involving apnea monitors, which sense breathing and heartbeats in babies and guard against Sudden Infant Death Syndrome. FDA tests on the monitor found "it was very sensitive to electromagnetic interference" and the movement of people nearby, says Mr. Silberberg. In one test, he says, "a simulated patient was not breathing, but the monitor showed it was."

Congressional testimony has also cited the Aequitron monitors for alarm failures.

No Lost Suits

In 1990, Aequitron sent out kits to owners of the monitors to improve the shielding. Mr. Samec says the company discovered that two-way radios and other transmitters near the monitors could trigger inaccurate alarms. The problem is that sleep-starved parents may turn off monitors that give false alarms. Mr. Samec says Aequitron has been sued over its monitors in cases where infants have died. But he says Aequitron hasn't lost any such suits, and "it's my belief that it's never been established that a malfunction has been associated with a death."

Some devices — such as apnea monitors, ventilators, and power wheelchairs — are screened by the FDA for vulnerability to EMI before reaching the marketplace. But many others are not.

The European Union is moving aggressively. On Jan. 1, 1996, it plans to impose mandatory standards for all electronic devices, including medical equipment, to ensure that they are immune to low-level electromagnetic interference.

In the U.S., the FDA is handling more than 5,000 applications for new medical devices, and sometimes EMI gets short shrift. Medical-device "reviewers are swamped as it is," says Mr. Silberberg. "Manufacturers are concerned about how long it takes to get things cleared. So it's hard to get the reviewers' time to discuss the problems with them."

Scrambled Chips

The heart of the problem is the microprocessor — the silicon chip that processes and stores data and acts as a central dispatcher, telling machines what to do and when to do it. "The problem with a microprocessor is it operates on a string of pulses," says Warren Boxleitner, vice president for technology at Thermo Voltek Corp., of Waltham, Mass. "If you apply a random pulse, which is what happens with electromagnetic interference, that scrambles the microprocessor. And it can totally screw up what it's trying to do." Thermo Voltek is attempting to build a business protecting devices from interference.

The FDA says growing awareness of the problem will lead to more safeguards. The Cellular Telecommunications Industry Association, worried about bans on phones or beepers, proposes creating a center for testing microprocessors to make sure they are adequately shielded against radio-frequency emissions. The Association for the Advancement of Medical Instrumentation, an Arlington, Va., group that sets voluntary standards in the U.S., recently created a committee to address electromagnetic problems.

Those measures are sure to affect devices of the future. But as Mr. Burlington at the FDA points out, "what we do with devices currently in the market" will remain a problem.

Epidemiologic Evidence of Radiofrequency Radiation (Microwave) Effects on Health in Military, Broadcasting, and Occupational Studies

JOHN R. GOLDSMITH, MD, MPH

In this opinion piece, the author brings together and discusses the collective relevance of possible health effects of microwave or radar exposure in military, broadcasting, and occupational circumstances, with a view to assuring optimal protective practices. Sources of the information presented include 1) historical data, 2) experiences of Polish soldiers, 3) a study of U.S. naval personnel using radar in the Korean War, 4) preliminary findings of exposures to the Skrunda, Latvia, transmitter, 5) data obtained near Hawaiian broadcasting facilities, 6) occupational studies of electronic and electrical workers, including ham radio operators, 7) reproductive outcomes among physiotherapists using short-wave and microwave diathermy, and 8) U.S. foreign service personnel exposed at Embassies in Eastern Europe. Some of the data are available in the peer-reviewed literature, others in abstracts, reports, or other non-peer-reviewed forms. Some were obtained under Freedom of Information statutes and are incomplete. For some of these, there is reason to believe that further evidence desired by the investigator was not obtained. Some are case-referent studies, but most are not. Some are ecological, and all are retrospective. Few have reliable dose estimations, and none has accurate dosage information on each subject. None includes evidence of tissue heating or any short-term effect. Possible outcomes considered included 1) blood count changes, 2) evidence of somatic mutation, 3) impairment of reproductive outcomes, especially increased spontaneous abortion, and 4) increase in cancer incidence and mortality, especially of the hematopoietic system, brain, and breast. The author presents evidence that sufficient microwave exposures are associated with all four of these outcomes, concluding that the possible effects and their timings with respect to exposure are qualitatively similar to those on ionizing radiation. A prudent course of action would be to provide more protection for those exposed than required by present regulations. No systematic effort to include negative studies is made; thus this review has a positive reporting bias. **Key words:** occupational cancer epidemiology; non-ionizing radiation; environmental cancer; leukemia; environmental mutagenesis.

INT J OCCUP ENVIRON HEALTH 1995;1:47-57.

Received from the Epidemiology and Health Services Evaluation Unit, Section on Occupational and Environmental Epidemiology, Faculty of Health Sciences, Ben Gurion University of the Negev, POB 653 Beer Sheva, Israel 84 320.

This article is an opinion piece, not intended to be a balanced presentation of the literature. It points out important unexplained positive findings from disparate studies and urges a less biased reassessment of the literature and follow-up studies than has thus far occurred. It should also be noted that the expected exposures associated with the proper use of domestic appliances using microwave energy are well below what is being discussed, and no risk from such use can be inferred from the data presented here.

As far back as 1943, Daily¹ had found a statistically significant increase in the concentration of immature red blood cells in radar-exposed workers, along with a high incidence of headache. Notwithstanding these findings, he concluded that "there has been no clinical evidence of damage to these personnel."² Early studies at Lockheed Aircraft were reported to show some blood abnormalities, but this was later dismissed on technical grounds.

Bach, using rats, reported changes in blood counts at about 13 mW/cm.³

Goldoni⁴ reported that 35 microwave-radiation-exposed workers had alterations in their peripheral blood counts. She compared male radar technicians involved in air traffic control with ten electronic technicians working far from any microwave source. The estimated exposures ranged from 10 μ W to 20 mW in a frequency range of 1,250 to 1,350 MHz. The numbers of leukocytes and erythrocytes was significantly lower in the blood samples from the radar-exposed technicians. In a follow-up study of 49 radar operators examined yearly, thrombocyte and reticulocyte counts decreased significantly but stayed within normal limits.^{4a}

STUDIES OF POLISH ARMY PERSONNEL

Szmigielski compiled data on the occurrence of cancer in the Polish army and characterized each soldier as to whether or not he had been exposed to radiofrequency (RF) and microwave (MW) radiation.⁵ Those exposed comprised about 3% of the population, and in the ini-

TABLE 1 Age-specific cancer incidence rates per 100,000/year among Polish soldiers exposed (EXP.) and not exposed (NEX) to microwave and radar during 1970-1979 and 1980-1989*

Age (Years)	EXP	1970-1979		1980-1989	
		NEX	Ratio	Ratio	Ratio
20-29	44.2	8.0	5.5	2.27	
30-39	81.7	17.2	4.7	2.74	
40-49	348.8	82.9	4.2	2.79	
50-59	558.6	353.4	1.6	2.06	

*Sources: Szmigielski.^{5a}

tial study, covering the years 1970-1979, the exposed accounted for 9% of all malignancies.⁶ Virtually the same pattern occurred in the second decade of follow-up, 1980-1989 (Table 1).

During the first follow-up period, the sites with the greatest excesses of malignancies were blood-forming organs and lymphatic tissues, ratio = 6.7; thyroid, 4.3; skin, including melanoma, 3.1; and esophagus and stomach, 3.2. During the second period, in addition to increases at these sites, colorectal cancer was increased among the exposed and so was brain cancer, with a 4.29 ratio.

The occurrences of the most common type of cancer, cancer of the lung, were the same in RF/MW-exposed soldiers and those who were not exposed.

U.S. NAVY RADAR PERSONNEL STUDY

Robinette and colleagues⁷ reported the results of a study of the effects on health of occupational exposures to microwave radiation (radar).

Mortality by cause of death, hospitalization during service, later VA (U.S. Veterans Administration) hospitalization, and VA disability were examined for about 40,000 enlisted naval personnel who had served during the Korean War, 1950-1954.

Although the abstract gives a global negative statement ("No adverse effects were detected in these indexes that could be attributed to potential microwave radiation exposures during the period 1950-1954"), some of the data in the article strongly suggest such adverse effects. A "low-exposure" group was defined as consisting of radiomen (9,253 men), radarmen (10,116), and aviation electrician's mates (1,412), and their experience was compared with that of a "high-exposure group" consisting of electronics technicians (13,078), fire-control technicians (3,298), and aviation electronics technicians (3,733).

What is not given is the mortality for men with no likely exposure to radar or other electronic gear. For the high-exposure group, an exposure estimate is attempted on the basis of the type of equipment on a given vessel to which each man was assigned and the lengths of his tours of duty. Such estimates were not made for the presumed low-exposure group. So we can

speculate that any possible effect is underestimated by these data, based solely on "low" versus "high" exposures. Table 2 shows, nevertheless, some data suggesting an effect of RF/MW exposures on lymphatic cancers and hematopoietic cancers (leukemias and blood cell cancers).

Although the differences in Table 2 do not reach customary levels of significance (they could be found by chance about once in ten samples), they nevertheless are also consistent with almost two times as much cancer of this type in the high-exposure group compared with the low-exposure group. The other disturbing finding is that after discharge from the service the high-exposure group had more frequent hospitalizations for diseases of the blood and blood-forming organs than did the low-exposure group. The high-exposure group experienced 12 hospitalizations for conditions of the blood and blood-forming organs after discharge from the service, when 7.6 were expected (this result was also not conventionally significant).

The study that generated the data in Table 2 has been interpreted in analyses used as the basis for health protection guidelines (see below): "No effect on mortality in male military personnel followed for over 20 years, exposed 2 years on average (over 40,000 personnel)".

SKRUNDA, LATVIA, STUDY

Located in rolling pastureland near Skrunda, Latvia, a Russian-built and Russian-operated microwave generator-detector system was designed to provide early warning of incoming ballistic missiles. The emission was at 154-162 MHz, with a set of 50-KW generators emitting 0.8-ms pulses at an energy level 50 times that allowed for continuous emissions.⁸

Growth retardation of pine trees and other ecological effects were reported⁹ at a meeting in June 1994, along with the results of two epidemiologic studies, one of cattle and one of humans.

Sixty-eight cows grazing for four months near the signal generators were found to have increased red blood cell micronuclei, compared with 105 cows from unexposed areas.¹⁰ Red blood cell micronuclei are thought to reflect mutagenesis.

TABLE 2 Deaths and relatively mortality of U.S. naval personnel from leukemias and blood cell types of cancer, 1950-1974, according to the estimated levels of exposure to microwave radiation*

	Exposure Level		
	Low	Medium	High
Deaths	26	12	8
Relative mortality (compared with all of the men)	0.88	1.04	1.64
Expected number of deaths	29.58	11.54	4.88

*Source: Robinette et al.⁷

Two hundred and thirty persons living and working near the radar-emitting source had significant increases in white blood cell counts and alterations in differential counts.¹¹ The effects were reported to be more pronounced among children.

Additional studies are under way.

STUDY OF BROADCASTING FACILITIES AND ADJACENT POPULATIONS IN HAWAII

Honolulu Broadcasting Tower

A unique opportunity to study the cancer incidences in the vicinities of radio broadcasting towers occurred in Honolulu, in part because the hills surrounding the town are a nature preserve, so the towers are located in populated areas of the city.

Anderson and Henderson, of the State Health Department, used data from the State Cancer Registry to compare the cancer incidences of nine census tracts that included broadcasting towers with those of two demographically similar tracts without such towers.¹² The U.S. Environmental Protection Agency (EPA) measured RF radiation at 21 locations, and reported that public exposures at 12 of the locations exceeded currently recommended limits. At two outdoor sites, exposures were greater than 1,000 $\mu\text{W}/\text{cm}^2$, but, in general, at distances greater than 100–150 feet from the towers, the exposure levels were below 100 $\mu\text{W}/\text{cm}^2$. EPA officials stated that RF radiation in Honolulu did not impose an *immediate* risk [my emphasis] to the public.

The data for all-site cancers and for leukemia overall for males and for females, age-adjusted, are shown in Table 3.

Anderson, the Deputy Health Officer for the State of Hawaii, said that the report had not been published, since it was intended to stimulate additional work in the field.

When the data are adjusted by race, rather than by age, the standardized incidence ratio (SIR) for total cancer, both sexes, in the tracts without towers is 1.07, compared with 1.88 in the tracts with towers, the latter being significantly elevated. For leukemia, the race-standardized SIRs are 0.59 and 2.08 for the tracts without and with broadcasting towers.

The authors point out that such an ecological design does not allow the establishment of a cause–effect relationship between cancer incidence and low levels of RF radiation, nor were there sufficient data to show a dose–response relationship. The study strongly indicates the need for more comprehensive studies and more powerful study designs.

The Childhood Leukemia Cluster on the Waianae Coast

In 1985, the Hawaii Department of Health was informed by a pediatric oncologist that he had seen an un-

TABLE 3 Age-adjusted cancer and leukemia annual incidence rates for males and for females in census tracts with broadcasting towers compared with those without such towers, Honolulu, Hawaii, 1979–1983, and comparison with statewide rates/100,000, 1978–1981*

Area	Males		Females	
	Incidence†	SIR†	Incidence†	SIR†
All-site cancers				
Tracts with towers	439.6 (488)†	1.45§	368.6 (417)	1.27§
Tracts without towers	318.0 (135)	1.05	246.8 (103)	0.85
Statewide	341.2 (5,468)		272.4 (4,658)	
Leukemia				
Tracts with towers	15.2 (15)	1.58	7.6 (8)	1.45
Tracts without towers	2.4 (1)	0.27	5.0 (2)	0.97
Statewide	9.4 (163)		5.3 (90)	

*Sources: Statewide data based on SEER Report 1973–1981¹¹; original incidence data given by Anderson and Henderson for five years.

†Number of cases in parentheses.

‡Standardized incidence ratio, standardized for age.

§Statistically significant, $p < 0.01$.

usual number of children with leukemia in the small communities of the Waianae Coast. This was confirmed by the Hawaii Cancer Registry in 1986. In 1990 the Department conducted a more detailed investigation and a case–control study.¹⁴

A case was defined as a child under 15 years of age, diagnosed as having acute leukemia between 1977 and 1990, who had spent at least 25% of his or her lifetime before diagnosis in the area. Fourteen children met this definition, of whom 12 were permanent residents and two had spent two to three days a week in the area. Based on the state's cancer registry, the number to be expected was about one every two years, or about seven cases in 14 years. Seven of the cases occurred during three years, 1982–1984. After 1985, the incidence returned to the expected one of a single case every two years.

Among the seven cases from 1982 to 1984, five were acute nonlymphocytic leukemia (ANLL), whereas statewide three of every four cases are acute lymphocytic leukemia (ALL); and six of the seven affected children were girls, whereas childhood leukemia is somewhat more common in boys. Four of the girls were between 9 and 12 years old, whereas the peak age of onset for childhood leukemia is around 3 years.

In the case–control study of 14 cases and 56 matched controls of the same sex and born within six months of the cases, no statistically significant risk factor was defined. Suggestive odds ratios were for other cases of cancer in the family (OR = 3.4 with 95% confidence limits of 0.70–16.41) and residence: ever lived within 2.2 miles of the Lualualei Naval Broadcast Facility (OR 2.2; CI 0.65–7.56) and its two “low-frequency” radio towers.

The authors report that improper storage of oil may have been associated with a risk of exposure to benzene, a known *adult* leukemogen. No adequate environmental measurement of radiation or of benzene exposure was available. Some measurements of electric or magnetic fields were made by the EPA in 1990, but primarily along roads, and not where the children lived and played. Nine of the 14 cases were of Hawaiian or part-Hawaiian ethnicity, and there is some evidence that Hawaiians and

Maoris of New Zealand have lower rates of ALL and higher rates of ANLL than do other ethnic groups.

The authors conclude that . . . "closeness to the low frequency radio towers at Lualualei Naval Station may have a weak association with leukemia, even though it is not statistically significant. This cannot be considered proof that anything emanating from the station actually caused the leukemia."

TABLE 4 Leukemia, acute leukemia, and acute myelogenous leukemia and exposures in electrical occupations*

Occupation	All Leukemia		Acute Leukemia		Acute Myelogenous Leukemia	
	RR	95% CL	RR	95% CL	RR	95% CL
Telegraph, radio and radar operators	1.8	1.4-2.6	2.1	1.3-3.3	2.6	1.4-4.4
Electronic technicians	1.3	0.9-1.8	1.8	1.0-3.0	1.9	0.8-3.8
Electrical and electronic engineers	1.2	1.0-1.5	1.8	1.2-2.3	1.9	1.3-2.7
Electricians	1.1	0.9-1.2	1.1	0.9-1.4	1.0	0.7-1.5
Electrical equipment assemblers	2.4	1.0-4.8	—	—	—	—
Power station operators	1.6	0.8-3.0	2.2	0.6-5.7	<1 expected	
Linemen	1.3	1.0-1.6	1.7	1.1-2.5	2.5	1.1-4.9
Phone repair and installation	0.9	0.6-1.3	1.1	0.6-1.8	1.0	0.4-1.8
Aluminum workers	1.9	1.2-2.9	2.6	1.3-4.6	—	—
Motormen, streetcar	1.7	0.7-3.3	<1 expected		—	—
Projectionists, movie	1.1	0.5-2.2	1.2	0.1-4.5	<1 expected	
Welders	0.9	0.7-1.2	1.0	0.7-1.5	1.7	0.5-4.5
TOTAL	1.2	1.1-1.3	1.4	1.2-1.6	1.5	1.2-1.8

*Source: Savitz and Calle.¹⁵

TABLE 5 Occupational exposures of electrical workers and electronic workers and leukemia, Washington State data 1950-1979*

Occupation	All Leukemia		PMR	Acute Leukemia		
	Observed	Expected		Observed	Expected	PMR
Radio and telegraph operators	5	4.5	111	3	1.3	239
TV and radio repairmen	5	3.2	157	4	1.4	291†
Electronic technicians	6	4.0	149	3	1.9	162
Subtotal	16	11.7	137	10	4.6	217
Electricians	51	37.0	138†	23	12.9	178†
Linemen	15	9.4	159	6	3.3	183
Power station operators	8	3.1	259†	3	1.1	282
Aluminum workers	20	12.6	189†	11	4.3	258†
Welders, flame-cutters	12	17.9	67	4	7.1	56
Projectionists, movie	4	1.7	234	1	0.9	111
Electrical engineers	7	6.1	114	2	2.1	97
Motormen, streetcar	3	1.7	175	0	0.4	0
TOTAL	136	99.2	137†	60	36.7	163†

*Source: Milham.¹⁶

†p < 0.01.

TABLE 6 Unconditional odds ratios (ORs) for recognized miscarriage and reported frequency of microwave or shortwave physiotherapy exposures per month in six months prior to and during the first trimester of pregnancy (all pregnancies)

No. of exposures	Cases	Microwave Controls	OR	Cases	Shortwave Controls	OR
0	1,459	1,494	1.00	1,158	1,176	1.00
<5 per month	88	86	1.05	239	203	1.20
5-20 per month	72	49	1.50*	180	166	1.10
>20 per month	45	29	1.59	72	84	0.87
Any	209	167	1.28*	499	472	1.07

* $p < 0.05$.

OCCUPATIONAL AND HAM RADIO OPERATORS' MORTALITY STUDIES

Cancer Studies in Electrical Workers

A series of 11 occupational mortality studies of workers exposed to electromagnetic fields was assembled by Savitz and Calle.¹⁵ The results for total leukemia show a modest excess risk for the men exposed, with enhanced risk for acute leukemia and especially acute myelogenous leukemia. Three of the studies were of incidence and eight, of mortality. The highest risk ratio for any occupational group, 2.6, for acute myelogenous leukemia, was found for telegraph, radio, and radar operators (95% CI 1.4-4.4). Table 4 summarizes these results. Data for Washington State alone, presented by Milham,¹⁶ are shown in Table 5.

Milham¹⁷ also examined mortality data for amateur radio operators in California and Washington from 1979 through 1984, based on the current license file of the Federal Communications Commission. Excess leukemia was practically confined to the operators in California, since in Washington there were five deaths, compared with 4.7 expected. In California, 31 leukemia deaths were reported, compared with 24.3 expected, and for tumors of other lymphatic tissues 38 deaths were observed, compared with 22.3 expected, a significant increase. Again, the highest risk was for acute myelogenous leukemia, with 15 cases observed compared with 8.5 expected. Milham suggested that about a third of the amateur radio operators were also occupationally exposed. It is estimated that amateur radio operators spend about six hours a week at their hobby, so it is reasonable to think of these data as reflecting something between an occupational exposure and a community exposure.

Physiotherapists and Spontaneous Abortion

Ouellet-Hellstrom and Stewart reported on the frequency of miscarriages among female physiotherapists using either radio- or microwave frequency electromagnetic radiation.¹⁸ The exposure frequency for shortwave medical therapy is 27.12 MHz, and those for microwave are 915 MHz and 2,450 MHz. Members of the American Physical Therapy Association ($n = 42,403$) were queried

as to pregnancy history and use of microwave or radiofrequency diathermy. It was possible to compare 1,791 miscarriages with 12,949 "control" pregnancies in a nested case-control design.

Table 6 gives the principal results, based on the unconditional odds ratios, with a chi-square test for trend, $p \leq 0.005$ for microwave, but nonsignificant for shortwave, exposures. There was no appreciable change in gradients when the data were adjusted for age at pregnancy, years elapsed between conception and interview, genitourinary conditions ever diagnosed, or previous fetal losses.

Figure 1 shows the proportions of miscarriages occurring before the seventh week of gestation in the four categories of exposure.

The authors discuss a number of possible biases and conclude "women who reported use of microwave diathermy at the time of conception were at increased risk of miscarriage. The risk increased with increasing exposure, and persisted even when known confounders were taken into consideration. Whether the excess risk is associated directly with the use of microwave diathermy per se or with something closely related to its use has yet to be determined. Women who reported using shortwave diathermy were not at increased risk."

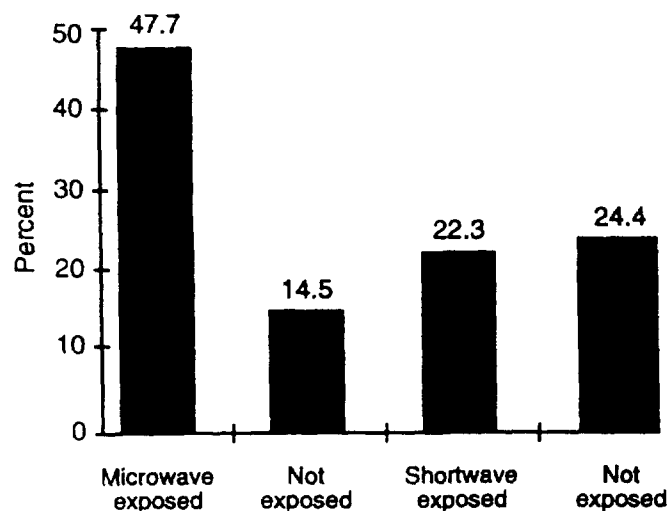


Figure 1—Proportion of miscarriages occurring before the seventh week of gestation, by exposure status: Physical Therapists Study, 1989-1990.

TABLE 7 Tabulation of results for tests of chromosomal changes

Mutagenic Level		No. of Subjects
5	Extreme	0
4	Severe	6
3.5	Intermediate	5
3	Moderate	7
2.5	Intermediate	5
2	Questionable	5
1	Normal	6
Growth failure		2

*Patients who repeat at level 3 or higher should not reproduce until six months after somatic levels have returned to 2 or 1.**

*Patients at level 4 should be withdrawn from "mutagenic exposure" and monitored each month until less than 3 is obtained on two consecutive samples.**

*Continuing statement in Dr. Jacobson's progress report concerning results.¹⁹

U.S. Foreign Service Workers in Eastern European Embassies

Between November 1962 and August 1963, highly directional, focused microwave transmissions beamed at the U.S. Embassy in Moscow were found and verified. A study of possible effects on chromosomes in blood was undertaken between February 1966 and June 1969 based on blood samples taken from 35 persons on duty in the Moscow Embassy between February 1966 and December 1966. A nongovernmental panel of experts advised that: "...no valid conclusions could be drawn from the study."¹⁹ Some of the difficulty seems to have been with poor sample collection and transmission. Some was due to inadequate compliance with the investigator's request for repeated sampling.

However, excerpts from a progress report on a contract between Dr. Cecil B. Jacobson, Head of the Reproductive Genetics Unit, George Washington University, and Dr. George I. Mishtowt, of the U.S. State Department, show the findings presented in Table 7. Dr. Jacobson wrote: "I feel impelled, as in past reports, to emphasize the necessity to study serial samples on the same individual and when possible to study the subject prior to exposure. There is a definite clinical necessity to follow all patients in category 3.5 and above as to the genetic consequences."¹⁹

"An attempt was made to quantitate the various types of chromosomal changes with their possible clinical severity, a difficult task given the current knowledge of human cytogenetics. . . . Total scope of the study design or results of the study have been kept confidential and no publication or presentations are allowed under contract stipulations. . . . Chromosomal changes in excess of 3 per 20 cells were felt to be significant in addition to isolated structural anomalies, however both should be confirmed in serial analysis. . . . The advantage of easy review was compromised by the financial limitation on the number of spreads (20) scored per sample. . . . All

records, slides and photographs utilized in this Contract are permanent and have been volunteered for review."¹⁹

What seems most significant is that about half of the persons tested for chromosomal abnormalities had enough evidence of damage that clinical guidelines would have had them restricted from reproductive activity until the abnormalities had been shown to have been abated. The persons involved were not informed, nor apparently were repeat tests done. (See above for evidence of occupational exposure and spontaneous abortion as a possible consequence of chromosomal abnormalities.)

A hematologic study was reported to the U.S. government on October 7, 1976, by James A. and Susan Tonascia.¹⁹ Among their findings were that comparing the Moscow-Embassy-based employees with data from Foreign Service examinations done in Washington, DC, "The differences between the two groups with respect to every parameter except monocytes (%) and counts) are highly statistically significant ($p < 0.001$) after appropriate transformation. Specifically, the Moscow group had a higher mean hematocrit, and the Moscow group had a lower neutrophil percentage, but higher percentages for the other three cell types (lymphocytes, eosinophils, and monocytes). The white blood cell counts were strikingly higher in the Moscow group. Several statistically significant changes over time occurred in the Moscow group; specifically, mean hematocrit increased and a threefold increase in monocyte count occurred. Neutrophil percentage fell and then rose and the reverse pattern was seen for the lymphocytes."

These data were never published. These comments are taken from the written record as obtained under the Freedom of Information Act.²⁰

A large-scale epidemiologic study of the foreign service workers in the U.S. Embassy in Moscow and their dependents was undertaken by a team headed by Professor Abraham Lilienfeld, from Johns Hopkins University.²¹ The most important comparison was with the employees of other East European embassies and their dependents, but it was not certain whether microwave exposures of the comparison group could also have occurred.

The occurrence of multiple-site cancers was far more frequent in the Moscow Embassy group than in any other population studied (1.33 sites/person, compared with 1.02 expected, based on the Third National Cancer Survey). This is even more surprising because multiple-site cancer is more characteristic in older populations, and this population of Embassy workers and dependents was relatively young.

There is documented evidence that the concerns expressed by the Johns Hopkins team were downgraded after a conference with the contract officer of the State Department.¹⁹ The suspicion expressed that other East European embassies had been irradiated was deleted because it was based on hearsay (i.e., reports of persons interviewed). Professor Lilienfeld was hospitalized at the time, but apparently agreed with the modifications

TABLE 8 Cancer mortality, observed and expected, for populations in the foreign service health study.*

Category	Moscow Embassy		Other Embassies		Both	
	Observed	Expected	Observed	Expected	Observed	Expected
All sites						
Employees	17	19.0	47	41.1	64	60.1
Adult dependents						
Lived in	5	1.5†	14	5.5†	19	7†
Lived out†	7	3.0†	19	6.1†	26	9.1†
Child dependents						
Lived in	2	0.5	1	1.3	3	1.8
Lived out	2	0.83	2	1.7	4	2.53
All children	4	1.33†	3	3.0	7	4.33
ALL	33	24.83	83	55.7†	116	80.53†
Leukemia						
Employees	2	0.8	3	1.7	5	2.5
Adult dependents						
Lived in	0	0.06	0	0.2	0	0.26
Lived out	0	0.14	0	0.24	0	0.38
Child Dependents						
Lived in	1	0.2	1	0.3	2	0.5†
Lived out	1	0.3	2	0.4	3	0.7†
TOTAL	4	1.5†	6	2.64†	10	4.14†
Brain tumors						
Employees	0	0.9	5	1.5†	5	2.4†
Adult dependents						
Lived in	0	0.05	1	0.17	1	0.22
Lived out	2	0.10†	0	0.20	2	0.3†
Child dependents						
Lived in	0	0.1	0	0.2	0	0.3
Lived out	0	0.2	0	0.2	0	0.4
TOTAL	2	1.35	6	2.27	8	3.62†
Breast cancers						
Employees	2	0.5†	3	1.2	5	1.7†
Adult dependents						
Lived in	1	0.40	2	1.3	3	1.7
Lived out	0	0.51	4	0.94†	4	1.35†
TOTAL	3	1.41	9	3.44	12	4.85†

*Source: Lilienfeld et al.²¹ tables 5.6, 7.12, 7.16.

†Either lived out or place of residence was unknown.

‡Observed deaths significantly increased, $p < 0.05$.

in his team's report. For example, the characterization of eight of 11 cancer deaths in the Moscow Embassy women and 15 of 31 cancer deaths in the women from the comparison embassies was said to be "disturbing," but the contract officer said this was too strong. The word was deleted. The Johns Hopkins group's characterization of the exposures as "regrettable" was deleted and the related verb was changed from "suffered" exposure to "experienced" exposure. Lilienfeld strongly recommended that additional followup studies be undertaken, since the latency periods for some types of cancer had been insufficient (usually requiring a minimum of 20 years) for cancer to occur if indeed it were to result from the exposures. There has been no follow-

up, so far as I know. Some white blood cell counts are reported in the body of the report, but they were taken from medical records at the "last examination after the index tour of duty."

Concerning the Lilienfeld study, the recent draft of criteria for health protection cites: "No effect on life span or *cause of death* [my emphasis] of 1,800 employees and 3,000 dependents of U.S. Embassy personnel." Some cancer mortality data from the study are shown in Table 8.

Overall there was no increase in cancers at all sites in the Moscow staff compared with the staffs in the other embassies. But there was an increase in leukemia, two deaths observed in the Moscow Embassy staff, where 0.8 case was expected. In the comparison embassies, three

leukemia deaths occurred in employees compared with 1.7 expected.

There were four deaths from cancers of the female genitalia, compared with 0.8 expected. In the comparison embassies there were three such deaths, compared with 1.3 expected. Four dependent children died of cancer among the Moscow Embassy families, compared with 1.5 deaths expected, whereas three such deaths occurred in the comparison populations, where 3.0 deaths were expected. Although exposure severity could not be dependably evaluated for all the subjects, among those for whom it could be evaluated, those with exposures had significantly more non-skin cancers than did those with no or uncertain exposures ($p = 0.02$).²² For adult dependents of Moscow Embassy workers, five malignant neoplasms were observed, compared with 1.5 expected, a statistically significant difference ($p < 0.05$). Among the dependent children, blood diseases (anemia) were significantly more frequent (3.4/1,000 person-years) in

the Moscow Embassy cohort than in the comparison resident families (1.3/1,000 person-years).

Such findings are *consistent with excess cancer incidences both in the Moscow Embassy cohort and in the other Eastern European embassy employees*, but the latter group was being treated as the reference population, which, if the supposition that they had also been irradiated were valid, would assure a spuriously negative finding.

To ignore these findings on the basis of "No effect on life span or cause of death" in setting human exposure standards is wrong. In the first place, the criteria are far too narrow; mortality is not the only relevant end-point. The positive or "findings of concern" are ignored. Increased cancer incidence among dependents is a non-trivial endpoint.

The estimated exposures of the Moscow Embassy cohort ranged from 5 $\mu\text{W}/\text{cm}^2$ to a maximum of 18 $\mu\text{W}/\text{cm}^2$ at various times.

TABLE 9 Summary and Evaluation*

Finding	Source†	Peer Reviewed	Presentation	Ecological	Truncated	Author's Estimate of Positive Association
Hematologic changes						
Incr. WBC	Skrunda ¹¹	-	+			- +
RBC change	Lilienfeld et al. ²¹	-	-		+	+
WBC change	Lilienfeld et al. ²¹	-	-		+	+
Historical	Steneck et al. ²	-	+			+ -
Hosp. blood dis.	Robinette et al. ⁷	+				+ -
Blood dis. child	Lilienfeld et al. ²¹	-	+			+ -
Thrombocytes and reticulocytes	Goldoni ^{4a}	?	+			+
Chromosomal changes						
WBC culture	Jacobson, cited in reference 19	-	-		+	+ -
Micronuclei (cows)	Skrunda ¹⁰	-	+			- +
Reproductive effects (spontaneous abortion)						
Dose-response in physiother.	Ouellet-Helstrom et al. ¹⁸	+				+
Incr. in reproductive problems	Lilienfeld et al. ²¹	-	+		+	+ -
Increased cancer incidence						
Polish army	Szmigielski ^{5,6}	?	+	+ -		+
Lymph + hem. CA	Robinette et al. ⁷	+				- +
Hawaii 1	Anderson and Henderson ¹²	-	-	+		+ -
Hawaii 2	Maskarinec and Cooper ¹⁴	-	+	- +		- +
Occupational and "ham" radio	Savitz and Calle ¹⁵ and Milham ^{16,17}	+		+		+ -
Moscow† vs. other employees	Lilienfeld et al. ²¹	-	+		+	-
Moscow + other employees	Lilienfeld et al. ²¹	-	+		+	+
Moscow vs. other dependents	Lilienfeld et al. ²¹	-	+		+	-
Moscow + other dependents	Lilienfeld et al. ²¹	-	+		+	+
Moscow vs. other children	Lilienfeld et al. ²¹	-	+		+	+
Moscow + other children	Lilienfeld et al. ²¹	-	+		+	+

*For each type of outcome, an assessment of the evidence is given as +, convincing; +-, suggestive, but important type of evidence is missing or negative; -negative; or -+, reported as negative, but including components that taken alone are suggestively positive.

†For reference citations, see the reference list.

‡Data for Moscow refer to all-site cancer. (See Table 8 for selected site-specific comparisons.)

RESUMÉ OF HEALTH EFFECTS AND THE EVIDENCE RELEVANT TO THEM

The foregoing findings are summarized and tentative interpretations are given in Table 9. The nature of the changes is obvious. If the finding is based on a peer-reviewed report, one cannot ignore the published conclusions, although where negative conclusions are cited but alternate interpretations are possible, the final column (the evaluation of the author) shows $-+$. Otherwise it would show $+$ if the finding were positive and statistically significant or $+/-$ if positive but not conventionally significant ($p < 0.05$).

If the finding has been presented at a meeting or in an abstract, or in the case of the Foreign Service Health Study, in the form of a report available on request, it is considered presented. Of course, those studies that were peer-reviewed need have no entry in this column.

Where the available exposure information is clearly nonspecific, but suggestive, the study can be described as "ecological," and although strong evidence of an effect may be present, the certainty that it is relevant to RF radiation exposure is unclear.

Where a study appears to have had positive findings when initiated, but was not completed, it is indicated as "truncated," and although the final column may show $+$, indicating that what information is available points to a positive association, the study findings should be confirmed.

The author makes no pretense of lack of bias in choosing the reports to present in this review. Resources did not allow a thorough search for negative findings, and the consequence is that the list of findings must be considered to manifest reporting bias.

It seems clear that more information is needed, that data for longer follow-up periods for the U.S. military and foreign-service worker cohorts should be collected and analyzed, and that a number of studies need to be presented more fully and evaluated by peer-review processes. Possibly the single most useful piece of data would be the subsequent health histories of the 35 foreign service workers whose white blood cell mutational status was determined in 1966–1969, and of whom 11 in a single sample indicated enough mutational change to require clinical follow-up in the view of the investigator.

Of these possible effects, the weight of evidence is greatest for cancer incidence and for effect on spontaneous abortion in the women who were pregnant while exposed. The other impressive item is the breadth of the possible effects, which if all are ultimately confirmed, is difficult to distinguish from the spectrum of effects one would expect from ionizing radiation. Despite the much larger amount of effort directed to studies of possible effects of (50–60 Hz) power-line exposures, this breadth of findings seems somewhat greater than an impressionistic view of current findings for low-frequency electromagnetic radiation exposures.

TABLE 10 Occupational exposure limits to radiofrequency electromagnetic fields averaged over any six-minute period during an eight-hour working day

Frequency (f) (MHz)	Unperturbed Root Mean Square Field Strength		Equivalent Plane- wave Power Density (mW/cm ²)
	Electric (V/m)	Magnetic (A/m)	
0.1–0.99	614	1.6/f	—
1.0–9.9	614/f	1.6/f	—
10–399.9	61	0.16	1
400–1,999.9	3 f ^{1/2}	0.008 f ^{1/2}	f/400
2,000–300,000	137	0.36	5

*f^{1/2} is the square root of frequency.

TABLE 11 General public exposure limits to radiofrequency electromagnetic fields averaged over any six-minute period during a 24-hour day

Frequency (f) (MHz)	Unperturbed Root Mean Square Field Strength		Equivalent Plane- wave Power Density (mW/cm ²)
	Electric (V/m)	Magnetic (A/m)	
0.1–0.99	87	0.23/f ^{1/2}	—
1.0–9.9	87/f ^{1/2}	0.23/f ^{1/2}	—
10–399.9	27.5	0.073	0.2
400–1,999.9	1.375 f ^{1/2}	0.0037 f ^{1/2}	f/2,000
2,000–300,000	61	0.16	1

*f^{1/2} is the square root of frequency.

REFLECTION OF THE EVIDENCE IN REGULATIONS

The Guidelines on Limits of Exposure to Radiofrequency Electromagnetic Fields in the Frequency Range from 100 kHz to 300 GHz,²³ prepared by the International Non-Ionizing Radiation Committee of the International Radiation Protection Association and published in *Health Physics* in 1988, was based on the 1981 review of biological effects compiled by the United Nations Environmental Program (UNEP)/WHO/IRPA as Environmental Health Criterion 16,²⁴ and it provided the scientific rationale for interim guidelines published in 1984. In the guidelines the basic limits for exposure are expressed by the specific absorption rate (SAR) in units of watts/kilogram. But for frequencies below about 10 MHz, SAR is noted to have limited usefulness, compared with current density generated in the body, which is estimated by the effective electric field strength and effective magnetic field strength, E_{eff} and H_{eff} , in units of V/m and A/m. Table 10 provides definitions for the exposure limits.

The occupational upper limits are also qualified by requiring that RF burns should be eliminated, which in most cases can be done by reducing the E value from 614 to 194 in the range of 0.1–0.99 MHz and from 614/f to 194/f^{1/2} in the range from 1.0 to 9.9 MHz.

The occupational exposures to frequencies above 10 MHz should not exceed a SAR of 0.4 W/kg averaged over 6 minutes and the whole body, provided that extremities shall not be exposed to more than 20 W/kg and that 10 W/kg shall not be exceeded in other parts of the body.

For the general public, the exposures are based on a limit of 0.08 W/kg (a fifth that for occupational exposure) (Table 11).

In the rationale for the standards, it is stated that the SAR is a convenient quantity to assess biological effects that depend on the increase in temperature associated with RF absorption. While stating that: "The emerging evidence for nonthermal mechanisms for biological effects cannot be ignored, and has to be considered in establishing exposure limits. . .," quantitative relationships for non-thermal effects in humans are not given. On the basis of behavioral changes in animals produced by and average SAR of 4 W/kg for less than an hour, a tenfold reduction to 0.4 W/kg is deemed permissible in order to account for prolonged exposures.

"Threshold exposure conditions for biological effects applicable to humans exposed to all parts of the frequency range and to all possible modulation frequencies do not exist. Thus safety factors must be incorporated into the exposure limits to allow not only for the lack of scientific data but for all possible conditions under which the exposure might occur." And "The committee considered the recent data linking electric and magnetic field exposure to increased cancer risks of congenital anomalies in various human populations. Available data are inconclusive and cannot be used for establishing exposure limits."

Before considering the adequacy of this set of recommendations, it is well to review the draft revision of Environmental Health Criterion 16, circulated by WHO and prepared in Rome in February 1990, and due to be reviewed in June 1990.²⁵ The draft report states "It is not clear whether RF or microwave exposure, either at thermal or non-thermal levels, can influence the process of carcinogenesis. However, some preliminary evidence suggests that exposure may either increase neoplastic transformation, or may act as a co-carcinogen. It is very important that these data be replicated and extended."

DISCUSSION AND THE ROLE OF EPIDEMIOLOGY

There is abundant evidence that hematologic abnormalities were found early in the Moscow Embassy employees. An effort was made to examine chromosomal abnormalities and, although the contractor kept requesting that serial studies be done, the only results available seemed to be cross-sectional ones. Even they show that there were substantially increased frequencies of mutation in 18 of the 36 individuals tested (including two with growth failure for the cultured cells). Only 17 were read as normal in a set of 53 tests of 43 persons.

However, a more recent study finds that physiotherapists exposed to microwaves have substantially in-

creased spontaneous abortion, while those exposed to short-wave diathermy do not.

While cancer and leukemia may be increased in those sufficiently exposed to microwave radiation, it is a more prudent base for the protection of exposed persons if hematologic or chromosomal reactions are used, since abnormalities in these indices can occur earlier and are reversible. Insufficient attention has been paid to reproductive risk.

While there is good evidence, both epidemiologically and from the laboratory, that the frequency of exposure is an important characteristic in determining whether unfavorable health effects may occur among those exposed, it is premature to define any frequency range as without effect.

Inevitably the populations likely to be found to have been exposed will be small. This makes it all the more important to undertake cooperative studies involving many similar exposures.

There are strong political and economic reasons for wanting there to be no health effect of RF/MW exposure, just as there are strong public health reasons for more accurately portraying the risks. Those of us who intend to speak for public health must be ready for opposition that is nominally but not truly, scientific.

At present there seems to be little interest in or understanding of epidemiologic information among regulatory bodies that should provide protection.²⁶ While we conduct epidemiologic studies as well as we possibly can, we who are concerned with health protection and careful identification of risks must also keep pressure on the regulatory agencies to include epidemiologic thinking in their work.

There is no reason for epidemiology to be limited to its historical role of body-counting when there are more useful contributions to make as well. These include epidemiologic studies of biological indicators of exposure and of risk, of hematologic changes (whether or not of clinical relevance), of evidence for chromosomal effects, and of reproductive outcomes in nominally high-risk groups.

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R E V I S E D

(2/2/95)

February 2, 1995

M E M O R A N D U M

TO: National Capital Planning Commission Chairman and Members

FROM: Dr. Patricia Elwood, Chairman *PE*
Antennae Task Force

SUBJECT: Summary of Antennae Task Force Meetings - July 28, 1994 to January 5, 1995

The establishment of the Task Force in the Spring of 1994 resulted from the Commission's continual concern about significant issues other than aesthetics in connection with the installation of Federal antennae and communication towers. The Chair, plus four-member Task Force consisting of Messers. Grandis, Finberg, Shiplett, and Colby, was Directed by the Commission to research these issues.

The Task Force has conducted four separate meetings to date to obtain more information on the possible biological effects of radio frequency (RF) radiation emitted from transmitting antennae (minutes of the meetings attached). The agenda of the first meeting conducted on June 30, 1994, concerned the possibility of consolidating antennae at one or a few locations, creating an antenna farm. Representatives from Washington International Teleport, one of the major teleports in the metropolitan area, were invited to explain the mission and operation of their company. The teleport is a collection of antennae and satellite dishes that operates by sending and receiving transmissions from a central site. The company successfully provides services to a variety of broadcast and cable networks, domestic and international. Federal agencies were also identified as user clients.

Additionally, the Task Force heard the testimony of two frequent D.C. witnesses regarding the biological effects of radio frequency radiation emitted from transmitting antennae. Mr. Phil Mendelson, an ANC Commissioner and former aide to a Councilmember, and Ms. Marija Hughes, a community activist who has herself suffered biological effects from such exposure, shared their concerns and knowledge about adverse effects of exposure to radiation. Ms. Hughes recommended that the Commission take the lead to regulate antennae construction and operation in the National Capital Region.

To understand the biological effects of RF radiation, the Task Force invited a medical panel of experts to address them on August 18, 1994. The consensus of the panel was that although there appears to be an ill effect on animals, it is still unknown if the effect of radiation on animals is similar to that on humans. The panel also suggested the following course of action:

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Recommendations

- 1) require Federal agencies to submit periodic information to the Commission regarding their maintenance and monitoring of antennae, conducted after Commission approval;
- 2) require Federal agencies to submit proof that the installed antenna will not emit radiation beyond a stated threshold;
- 3) consider a new requirement that restricts new antennae in specified areas (creating exclusion zones);
- 4) investigate a partnership arrangement with the National Council on Radiation Protection and Measurement;
- 5) investigate restricting public access to ground installation antennae with structural barriers; and
- 6) require submitting Federal agencies to measure the RF radiation level of new antennae and the cumulative RF radiation level when measured with existing antennae in the vicinity, as well as future RF levels, using acceptable calculation models. These recommendations were later rewritten in a separate memorandum outlining specific recommendations suggested by the medical panel, dated October 6, 1994 and contained in this packet.

On October 20, 1994, the Task Force spoke with Dr. Thomas Koval, a research scientist with the National Council on Radiation Protection and Measurements (NCRP). Dr. Koval offered several suggestions that the Commission could undertake. He suggested that the NCRP could possibly assist the Commission in revising its antennae submission guidelines and perhaps undertake research in the area of cumulative biological effects of RF radiation exposure. At the same meeting, the Task Force was provided with copies of ordinances that govern the usage of telecommunication facilities in selected cities, counties and states in the country (summary information matrix is attached).

Finally, on January 5, 1995, the Task Force invited representatives of the American Personal Communications (APC) Company to describe that company's mission and to explain the operation of the proposed regional Personal Communications System in the National Capital Region. Because of the extensive network of the proposed system requiring the installation of 200 to 300 antennae on both private and public lands (including Federal property), the Task Force expressed concern about the cumulative impacts of these antennae, as well as the additional antennae constructed from competing antenna service companies in the National Capital Region. The task force requested that the representatives of APC return with a comprehensive plan for antenna needs. An additional request was subsequently made that the APC representative make a presentation before the full Commission.